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You see also from the above that for these two plates, 1619 and 1620, there was one position which was useful; and it is not impossible that on a great part of your plates you will be able to find one position for stereo-comparing work.

Now you can imagine how difficult it is for me to bear the responsibility to give you advice whether to procure a stereo-comparator or not. There is no doubt you will not have the full benefit of the instrument, because in many cases the réseau makes the use of the stereo-comparator impossible; on the other hand, in many cases you will have some great *profit* of its use.

Excuse me that I can give you no deciding answer, but the reason lies not in my hands, it reposes on the difficulty of the matter.

With kind regards, yours very truly,
MAX WOLF.

*Heidelberg:* 1903 *July* 5.

## *An Examination of the Relative Star-density in Different Parts of the Plates forming the Harvard Photographic Sky-map.* By J. C. W. Herschel, B.A.

In *Monthly Notices*, lxii. 1902 April, p. 444, Professor Turner gave diagrams for five different observatories, which use essentially similar objectives, showing that the relative number of star images photographed in different parts of a plate varies by about 50 per cent., and can be expressed in terms of the distance from the centre; there is no continuous area of useful uniformity; on the other hand, he showed that the *doublet* used for the C.P.D. gives a sensibly uniform field over 6° × 6°.

Professor Pickering has recently issued a set of fifty-five photographs taken with a doublet as "a photographic map of the entire sky" (*Harvard Circular*, No. 71), being picked plates chosen out of those with which a continuous watch has been kept upon the sky at Harvard College and Arequipa for many years.

It seems useful, therefore, to ascertain whether any considerable area of *these* plates has reasonable uniformity of star-density, and if so to what extent.

I am indebted to Professor Turner for suggesting this question, and for the use of the set of plates at the Oxford University Observatory.

The photographs were taken with a portrait lens of one inch aperture and thirteen inches focal length, and they cover about 30° square. Twelve plates (Nos. 1, 2, 6, 10, 16, 22, 28, 34, 40, 46, 50, and 54) were chosen, to cover an entire belt of the sky passing through the poles and cutting the Milky Way nearly at right angles; in fact, the plate centres lie along the equinoctial colure, at declinations +60, +30, 0, −30, −60, on both the $0^h$ and $xii^h$

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circles, and one at $0^h + 90°$ and $9^h - 85°$. The plates not having réseaux themselves, a separate plate with a 5 mm. réseau of thirty-two squares to a side was used, and this covered most of the photograph. Some difficulty was found at first owing to grit in the film of the réseau (due perhaps to its having unfortunately been washed in the hard Oxford water instead of distilled water). One naturally puts réseau and photograph film to film, so that both may be in focus together; but when, as in this case, there is only a single exposure, spots in focus are easily mistaken for stars. For counting purposes, where one is not *measuring* from the réseau lines, this difficulty is got over by putting réseau and plate glass to glass, films outwards instead of together, and the spots are then so much out of focus as to be invisible, or readily distinguishable from stars, while the réseau is still in good enough focus for the purpose of defining a small area.

As a rapid way of estimating the number and distribution of star images, I counted only those in the diagonal line of réseau squares. I therefore mounted the plates diagonally in the counting microscope, so that the eye followed along a diagonal when the frame was moved horizontally.

I need not give the figures for each plate. The star-density curves, when reduced to percentages of the maximum density, are much the same for all of them. One plate, No. 50, was so much in the thick of the Milky Way (near the Southern Cross) that the number of stars—as many as 250 in one réseau square—quite swamped the other counts, and it would give a false impression to include it in ascertaining the *average* star-density, though it does not make much difference in the *form* of the density curve itself. The table below shows this. (The northern Milky Way plate happens to come on a poor region of the Milky Way, and the number of stars photographed, though well above the average, is not disturbingly abnormal.) The réseau lines are numbered from 0 at the centre to 16 at the corner, and the figures for equal areas on the sky are deduced from those for equal areas on the plate by multiplying them by the cube of the secant of the distance from the centre, given in the last column.

The diagram shows the result better. We see that up to about 9° from the centre the star-density is fairly uniform, the undulations being doubtless due to incomplete compensation of the lenses, remarkably so at the centre of view. A sharp fall follows, and at 15° from the centre the density has fallen to about 50 per cent. of the maximum.

Here, then, we have a central area approaching to the uniformity of the doublet type of lens used for the C.P.D., apparently combined with the falling off beyond it of the single objective type; but with this difference, that whereas the curve required by Professor Turner's formula* is anticlinal, the curve of the Harvard plates is synclinal, and also the outer part is not a continuation by reversal of the inner part. (Compare Figs. 1 and 2.)

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* P. 441 in *loc. cit.*

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| Réseau square. | Number of stars photographed at different distances from the plate centre on equal areas on the plate | | on the sky | | Star-density (Number per sq. deg.) | Distance from centre. | |
|---|---|---|---|---|---|---|---|
| | Incl. pl. 50. | Excl. pl. 50. | Incl. pl. 50. | Excl. pl. 50. | Excl. pl. 50. | ° | ′ |
| 0 to 1 | 49·8 | 27·0 | 49·8 | 27·0 | 36·9 | 0 | 37 |
| 1 „ 2 | 56·0 | 30·9 | 56·0 | 30·9 | 42·2 | 1 | 50 |
| 2 „ 3 | 55·1 | 28·2 | 55·1 | 28·2 | 38·5 | 3 | 4 |
| 3 „ 4 | 53·5 | 30·0 | 54·0 | 30·3 | 41·4 | 4 | 17 |
| 4 „ 5 | 53·1 | 31·2 | 53·6 | 31·5 | 43·0 | 5 | 30 |
| 5 „ 6 | 52·3 | 30·9 | 53·3 | 31·5 | 43·0 | 6 | 43 |
| 6 „ 7 | 50·7 | 30·4 | 52·2 | 31·3 | 42·8 | 7 | 56 |
| 7 „ 8 | 52·4 | 29·8 | 54·5 | 31·0 | 42·4 | 9 | 8 |
| 8 „ 9 | 38·5 | 23·2 | 40·4 | 24·4 | 33·3 | 10 | 20 |
| 9 „ 10 | 34·2 | 20·6 | 36·3 | 21·8 | 29·8 | 11 | 30 |
| 10 „ 11 | 30·3 | 18·0 | 32·7 | 19·4 | 26·5 | 12 | 41 |
| 11 „ 12 | 27·5 | 18·0 | 30·0 | 19·6 | 26·8 | 13 | 50 |
| 12 „ 13 | 24·2 | 15·3 | 26·9 | 17·0 | 23·2 | 15 | 0 |
| 13 „ 14 | 21·1 | 13·7 | 23·8 | 15·5 | 21·2 | 16 | 8 |
| 14 „ 15 | 19·5 | 13·5 | 22·4 | 15·5 | 21·2 | 17 | 15 |
| 15 „ 16 | 15·7 | 11·0 | 18·4 | 12·9 | 17·6 | 18 | 23 |
| Curve in diagram. | *a* | *b* | *c* | *d* | *e* | | |

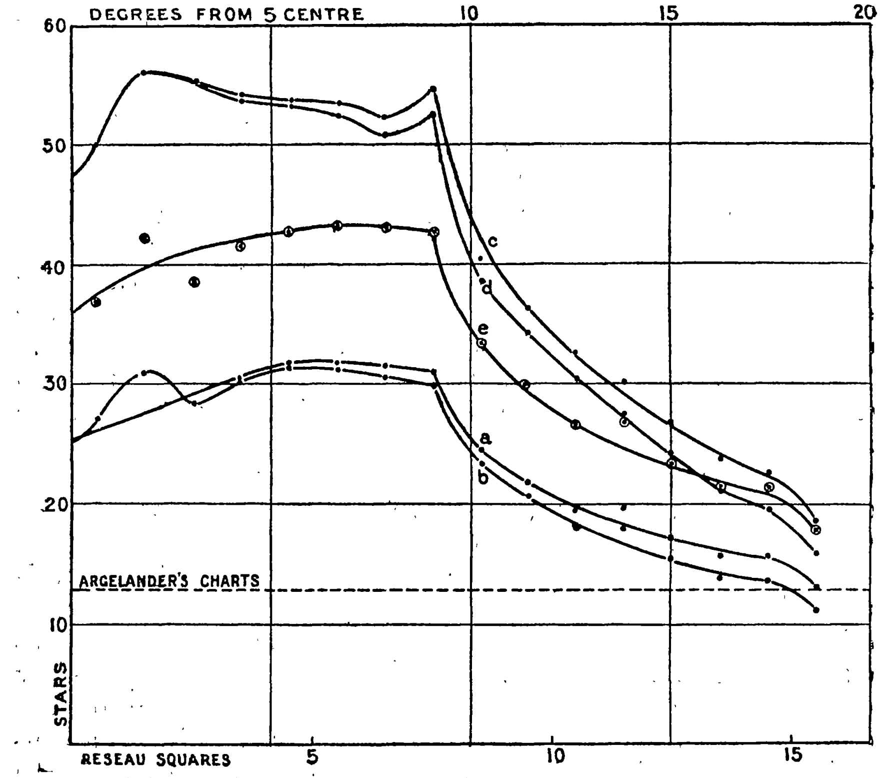

Fig. 1

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The change of star-density, once it begins, is more rapid with the doublet than with the single objective. Central uniformity is gained at the expense of the outlying parts, and it is possible that the Cape doublet would show a falling off of the same character were the field extended a few degrees further. The advantage of uniformity over the *whole* plate is obvious: it is the ideal of the lensmaker and the astronomer. The attractiveness of the C.P.D. plates in this respect is attained by confining the field of view within the limit indicated by the curves. The Harvard plates exceed this limit, but nevertheless it is satisfactory to find that the Harvard plates over their large area of 30° × 30° have the same range of star-density (from 50 to 100 per cent.) as the astrographic plates over their area of 2° × 2°, with the additional merit of having the considerable area of 18° in diameter of practically uniform star-density.

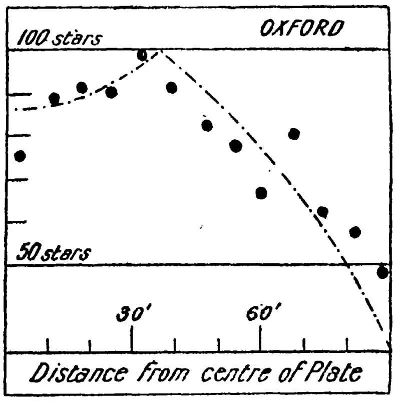

Fig. 2. (From Professor Turner's paper.)

It may be of interest to compare this star-density with Argelander's charts. To find this approximately, I drew circles on the charts a degree across at the plate centres and réseau corners, and laid down a pair of rulers touching them in pairs, centre to corner, and counted the stars between them. In this way I was counting approximately the same parts of the sky as I had counted on the photographs. The projection of Argelander's charts is not such as to make it exactly so, but it is near enough for the present purpose. I could, of course, only do this for the regions included in Argelander and Schonfield's charts, namely plates 1, 2, 6, 10, 16, 22, and 28. The count gave an average star-density of 12·9—less than the corner réseau square (which was not quite the corner of the plate). The mean Harvard star-density within the 18° circle is 41·3, so that the Harvard map, *over its area of reasonably uniform star-density*, shows nearly three times as many stars as Argelander, and is therefore comparable with the astrographic catalogue plates as well in respect to the magnitude of stars shown as to the relative star-density over the plate.

1903 *December.*